What is claim is:

1. A transparent High Energy Beam Sensitive-glass (HEBS-glass) which in bodies of 0.090 inch cross section will exhibit the following properties:

(a) the transmittance is more than 88% at 436 nm; and

(b) upon exposure to an electron beam using an electron beam pattern generator operated with a write scheme having a value of acceleration voltage selected from 20 to 30 kV, a value of addressing grid size selected from 0.1 to 0.4 micrometer, and a value of beam current selected from 25 to 250 na, the electron beam darkening sensitivity in the linear portion of the sensitivity curve, is at least 2.454 unit of optical density value in the spectral range of 365 nm to 630 nm per milli coulomb/cm^2.

Said HEBS-glass having a base glass composition consisting essentially on the mole % oxide basis 11.4 to 17.5% of one or more alkali metal oxide, 2.4 to 10.2% total of photosensitivity inhibitors and RS suppressing agents including 2.4 to 10.2% TiO_2, 1.1 to 2.4% Al_2O_3, 0 to 4.6% B_2O_3, 3.7 to 13.2% ZnO, 0.5 to 6% Cl and 58.2 to 78.8% SiO_2.

2. A transparent HEBS-glass of Claim 1 wherein the HEBS-glass has utility in making a gray scale mask with multi-gray levels, each of said gray levels having a predetermined optical density value which is obtained through exposure to a predetermined electron dosage.

3. A transparent HEBS-glass of Claim 2 wherein said gray scale mask can be utilized in making three dimensional microstructures with general three dimensional surfaces in photoresist through a single optical exposure in a photolithographic process.

4. A transparent HEBS-glass of Claim 3 wherein the profile of said three dimensional surface is transferred into a substrate material using an etching process.

5. A transparent HEBS-glass of Claim 4 wherein the three dimensional microstructures include micro-optical devices, microelectrical devices, micro-opto-electromechanical devices, integrated optical devices, two-dimensional fanout gratings, optical interconnects, fiber pigtailing, diffractive optical elements, refractive microlens arrays, microprism arrays, micromirror arrays and Bragg grating.

6. A transparent HEBS-glass of a Claim 4 wherein the three dimensional microstructures include 1.) Tapered structures for microelectronics, e.g. tapered structures in thick polyimide to realize electrical connection between two metallic layers separated by the thick polyimide, 2.) Micro optical devices such as diffractive and refractive micro lenses, bifocal intraocular lenses, widely asymmetric DOE, miniature compact disc heads, anti reflective surface, complex imaging optics, grating couples, polarization-sensitive beam splitters, spectral filters, wavelength division multiplexers, elements for head-up and helmet mounted display, for focal plane optical concentration and optical efficiency enhancement, for color separation, beam shaping, and for miniature optical scanners, microlens arrays, diffraction gratings, laser diode array collimators and correctors, aberration correction, hybrid optics, microprism arrays, micromirror arrays and Bragg gratings, 3.) Integrated optical components, two dimensional fanout gratings, optical interconnect, signal switching, fiber pig tailing, DOE to couple light from a laser into a fiber, 4.) Micro-electro-mechanical (MEM) devises for sensors and actuators in automotive, machine

tools, robotics and medical instrumentation, also devices for applications in micro valves, inertial micro sensors, micro machined RF switches, GPS component miniaturization, and a host of other sensors and actuators for applications to space, air, land, and sea vehicles, as well as industrial, biotechnology and future consumer electronics, 5.) Micro-opto-electro-mechanical (MOEM) devices such as laser scanners, optical shutters, dynamic micro mirrors, optical choppers and optical switches

7. Another product of the present invention is a transparent HEBS-glass which in bodies of 0.090 inch cross section will exhibit the following properties:

(a) the transmittance is more than 88% at 436 nm ; and

(b) upon exposure to a value X in milli coulomb/cm^2 of electron dosage with an electron beam writer operated at a beam acceleration voltage of 20 kV, an addressing grid size of 0.2 micrometer and a beam current of 150 na The glass will darken to a net optical density value Y at 435 nm substantially in accordance with the equation stated immediately below;

$$Y = -278.14x^6 + 503.66x^5 - 329.14x^4 + 89.552x^3 - 11.422x^2 + 5.4742x$$

Said HEBS-glass having a base glass composition consisting essentially on the mole % oxide basis 11.4 to 17.5% of one or more alkali metal oxide, 2.4 to 10.2% total of photosensitivity inhibitors and RS suppressing agents including 2.4 to 10.2% TiO_2, 1.1 to 2.4% Al_2O_3, 0 to 4.6% B_2O_3, 3.7 to 13.2% ZnO, 0.5 to 6% Cl and 58.2 to 78.8% SiO_2, has utility in making a gray scale mask with multi-gray levels, each of said gray levels having a predetermined optical density value which is obtained through exposure to a predetermined electron dosage, said gray scale mask can be utilized in making three dimensional microstructures with general three dimensional surfaces in photoresist through a single optical exposure in a photolithographic process.

8. A transparent HEBS-glass of Claim 7 of wherein the profile of said three dimensional surface is transferred into a substrate material using an etching process.

9. A transparent HEBS-glass of Claim 8 wherein the three dimensional microstructures include micro-optical devices, microelectrical devices, micro-opto-electromechanical devices, integrated optical devices, two-dimensional fanout

gratings, optical interconnects, fiber pigtailing, diffractive optical elements, refractive microlens arrays, microprism arrays, micromirror arrays and Bragg grating.

10. A transparent HEBS-glass of Claim 8 wherein the three dimensional microstructures include 1.) Tapered structures for microelectronics, e.g. tapered structures in thick polyimide to realize electrical connection between two metallic layers separated by the thick polyimide, 2.) Micro optical devices such as diffractive and refractive micro lenses, bifocal intraocular lenses, widely asymmetric DOE, miniature compact disc heads, anti reflective surface, complex imaging optics, grating couples, polarization-sensitive beam splitters, spectral filters, wavelength division multiplexers, elements for head-up and helmet mounted display, for focal plane optical concentration and optical efficiency enhancement, for color separation, beam shaping, and for miniature optical scanners, microlens arrays, diffraction gratings, laser diode array collimators and correctors, aberration correction, hybrid optics, microprism arrays, micromirror arrays and Bragg gratings, 3.) Integrated optical components, two dimensional fanout gratings, optical interconnect, signal switching, fiber pig tailing, DOE to couple light from a laser into a fiber, 4.) Micro-electro-mechanical (MEM) devises for sensors and actuators in automotive, machine tools, robotics and medical instrumentation, also devices for applications in micro valves, inertial micro sensors, micro machined RF switches, GPS component miniaturization, and a host of other sensors and actuators for applications to space, air, land, and sea vehicles, as well as industrial, biotechnology and future consumer electronics, 5.) Micro-opto-electro-mechanical (MOEM) devices such as laser scanners, optical shutters, dynamic micro mirrors, optical choppers and optical switches.

11. A Laser Direct Write-glass (LDW-glass) which is a High Energy Beam Sensitive-glass (HEBS-glass) having been uniformly darkened to a predetermined optical density value, said predetermined optical density value is at least the maximum optical density value of a pre-designed gray scale mask with multi-gray levels, said LDW-glass prior to being darkened with an electron beam or a flood electron gun is a transparent HEBS-glass which in bodies of 0.090 inch cross section will exhibit the following properties:

(a) (a) the transmittance is more than 88% at 436 nm ; and

(b) upon exposure to an electron beam with a flood electron gun or with an electron beam pattern generator operated at a value of acceleration voltage selected from 20 to 30 kV, the electron beam darkening sensitivity in the linear portion of the sensitivity curve, is at least 2.454 unit of optical density value in the spectral range of 365 nm to 630 nm per milli coulomb/cm^2.

Said HEBS-glass having a base glass composition consisting essentially on the mole % oxide basis 11.4 to 17.5% of one or more alkali metal oxide, 2.4 to 10.2% total of photosensitivity inhibitors and RS suppressing agents including 2.4 to 10.2% TiO_2, 1.1 to 2.4% Al_2O_3, 0 to 4.6% B_2O_3, 3.7 to 13.2% ZnO, 0.5 to 6% Cl and 58.2 to 78.8% SiO_2, said gray scale mask is made by exposure to a focused laser beam, said multi-gray levels are made using laser write speed and/or laser beam intensity and/or number of retraces as a variable write parameters.

12. A LDW-glass of Claim no. 11 wherein said gray scale mask can be utilized in making three dimensional microstructures with general three dimensional surfaces in photoresist through a single optical exposure in a photolithographic process.

13. A LDW-glass of Claim 12 wherein the profile of said three dimensional surface is transferred into a substrate material using an etching process.

14. A LDW-glass of Claim 13 wherein the three dimensional microstructures include micro-optical devices, microelectrical devices, micro-opto-electromechanical devices, integrated optical devices, two-dimensional fanout gratings, optical interconnects, fiber pigtailing, diffractive optical elements, refractive microlens arrays, microprism arrays, micromirror arrays and Bragg grating.

15. A transparent HEBS-glass of a Claim 13 wherein the three dimensional microstructures include 1.) Tapered structures for microelectronics, e.g. tapered structures in thick polyimide to realize electrical connection between two metallic layers separated by the thick polyimide, 2.) Micro optical devices such as diffractive and refractive micro lenses, bifocal intraocular lenses, widely asymmetric DOE, miniature compact disc heads, anti reflective surface, complex imaging optics,

grating couples, polarization-sensitive beam splitters, spectral filters, wavelength division multiplexers, elements for head-up and helmet mounted display, for focal plane optical concentration and optical efficiency enhancement, for color separation, beam shaping, and for miniature optical scanners, microlens arrays, diffraction gratings, laser diode array collimators and correctors, aberration correction, hybrid optics, microprism arrays, micromirror arrays and Bragg gratings, 3.) Integrated optical components, two dimensional fanout gratings, optical interconnect, signal switching, fiber pig tailing, DOE to couple light from a laser into a fiber, 4.) Micro-electro-mechanical (MEM) devises for sensors and actuators in automotive, machine tools, robotics and medical instrumentation, also devices for applications in micro valves, inertial micro sensors, micro machined RF switches, GPS component miniaturization, and a host of other sensors and actuators for applications to space, air, land, and sea vehicles, as well as industrial, biotechnology and future consumer electronics, 5.) Micro-opto-electro-mechanical (MOEM) devices such as laser scanners, optical shutters, dynamic micro mirrors, optical choppers and optical switches.

16. A Laser Direct Write-glass (LDW-glass) which is a High Energy Beam Sensitive-glass (HEBS-glass) having been uniformly darkened to a predetermined optical density value, said predetermined optical density value is at least the maximum optical density value of a pre-designed gray scale mask with multi-gray levels, said LDW-glass prior to being darkened with an electron beam or a flood electron gun is a transparent HEBS-glass which in bodies of 0.090 inch cross section will exhibit the following properties:

(a) (a) the transmittance is more than 88% at 436 nm, and

(b) upon exposure to an electron beam with a flood electron gun or with an electron beam pattern generator operated at a value of acceleration voltage selected from 10 to 100 kV, the HEBS-glass is darkened to a predetermined optical density value which is at least the maximum optical density value of a pre-designed gray scale mask with multi-gray levels, said HEBS-glass having a base glass composition consisting essentially on the mole % oxide basis 11.4 to 17.5% of one or more alkali metal oxide, 2.4 to 10.2% total of photosensitivity inhibitors and RS

suppressing agents including 2.4 to 10.2% TiO_2, 1.1 to 2.4% Al_2O_3, 0 to 4.6% B_2O_3, 3.7 to 13.2% ZnO, 0.5 to 6% Cl and 58.2 to 78.8% SiO_2, said gray scale mask is made by exposure to a focused laser beam, said multi-gray levels are made using laser write speed and/or laser beam intensity and/or number of retraces as a variable write parameters.

17. A LDW-glass of Claim 16 wherein said gray scale mask can be utilized in making three dimensional microstructures with general three dimensional surfaces in photoresist through a single optical exposure in a photolithographic process.

18. A LDW-glass of Claim 17 wherein the profile of said three dimensional surface is transferred in to a substrate material using an etching process, the three dimensional microstructures include micro-optical devices, microelectrical devices, micro-opto-electromechanical devices, integrated optical devices, two-dimensional fanout gratings, optical interconnects, fiber pigtailing, diffractive optical elements, refractive microlens arrays, microprism arrays, micromirror arrays and Bragg grating.

19. A LDW-glass of a Claim 18 wherein the three dimensional microstructures include: 1.) Tapered structures for microelectronics, e.g. tapered structures in thick polyimide to realize electrical connection between two metallic layers separated by the thick polyimide, 2.) Micro optical devices such as diffractive and refractive micro lenses, bifocal intraocular lenses, widely asymmetric DOE, miniature compact disc heads, anti reflective surface, complex imaging optics, grating couples, polarization-sensitive beam splitters, spectral filters, wavelength division multiplexers, elements for head-up and helmet mounted display, for focal plane optical concentration and optical efficiency enhancement, for color separation, beam shaping, and for miniature optical scanners, microlens arrays, diffraction gratings, laser diode array collimators and correctors, aberration correction, hybrid optics, microprism arrays, micromirror arrays and Bragg gratings, 3.) Integrated optical components, two dimensional fanout gratings, optical interconnect, signal switching, fiber pig tailing, DOE to couple light from a laser into a fiber, 4.) Micro-electro-mechanical (MEM) devises for sensors and actuators in automotive, machine tools, robotics and medical instrumentation, also devices for applications in micro valves, inertial micro sensors, micro machined RF switches, GPS component

miniaturization, and a host of other sensors and actuators for applications to space, air, land, and sea vehicles, as well as industrial, biotechnology and future consumer electronics, 5.) Micro-opto-electro-mechanical (MOEM) devices such as laser scanners, optical shutters, dynamic micro mirrors, optical choppers and optical switches.

20. A transparent HEBS-glass of Claim 1 wherein the write scheme is selected from the write schemes of Table 2 which is incorporated herein by reference, said electron beam darkening sensitivity of the HEBS-glass is substantially represented by the sensitivity curve corresponding to that of the chosen write scheme of Table 2.

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